AF 40

Name _____ Class _____ Date _____

Molar Volume of a Gas

Experiment 14

1 M of Mg = 1.64 g

Process Objectives

- To measure the volume of H_2 collected in the experiment.
- To formulate a balanced equation for the experiment.

Learning Objectives

- To determine the volume of one mole of a gas at standard temperature and pressure.
- To discover the difference that water vapor pressure will make in the total pressure of a gas collected over water.

Introduction

When magnesium metal reacts with hydrochloric acid, hydrogen gas is produced. The volume of this gas can be measured by using a eudiometer. Knowing the number of moles of magnesium used, we can calculate the volume of hydrogen produced per mole of magnesium consumed. The balanced equation for this reaction allows us to determine the volume that one mole of gas occupies at a specified temperature and pressure.

Magnesium is the least dense structural metal. Because of its lightness it is often alloyed with aluminum and used to make custom-designed racing car wheels, called MAG wheels. Both magnesium and aluminum are very reactive with acids, such as with the hydrochloric acid used in this experiment. This explains why manufacturers of these very expensive wheels warn consumers that the use of any acid cleaning product will affect the surface and void the warranty.

Refer to Chapter 12, Section 12.1 and 12.3 for additional information on gas volumes.

Safety

Take the necessary precautions before beginning this experiment. Wear safety goggles, apron, and gloves. Read all safety cautions in your procedures and discuss them with your teacher. It is important to use good safety techniques while conducting experiments. See pages 8 through 11.

Apparatus

beakers, 400 mL, 50 mL
thermometer
hydrometer jar or 1000 mL graduated cylinder
ring stand
buret clamp
centimeter rule
rubber stopper (one-hole, #00)
eudiometer, 50 mL

Materials

magnesium ribbon, untarnished
hydrochloric acid, 6 *M*
thread

Recording Your Observations

After completing each step of the procedures, record your observations in the Data Table.

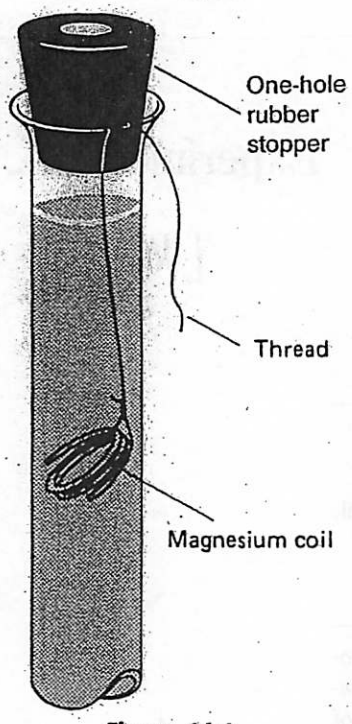

Figure 14-1

Procedures

1. Fill a 400 mL beaker two-thirds full of water. If possible, use water that has adjusted to room temperature. Obtain a piece of magnesium ribbon from your instructor. Measure the length of magnesium ribbon to the nearest 0.1 cm. (Note: If your piece of ribbon exceeds 4.5 cm, then return it for a smaller one.) Record the length of the ribbon in your Data Table. Also record the mass of one meter of this ribbon. You can obtain this mass from your teacher.
2. Roll the length of magnesium ribbon into a loose coil. Tie it with one end of a piece of thread, approximately 25 cm in length, in such a manner that all the loops of the coil are tied together.
3. This next procedure requires the use of 6 *M* hydrochloric acid. You may want to practice Procedures 3 to 6 by using water in place of the acid. When you have mastered the technique using water, proceed to use the acid.

CAUTION **Hydrochloric acid is caustic and corrosive. Avoid contact with skin and eyes. Avoid breathing the vapor. Make certain that you are wearing safety goggles, apron, and gloves when working with the acid. If any acid should splash on you, immediately flush the area with water and then report the incident to your teacher. If you should spill any on the counter top or floor, ask your teacher for the appropriate spill package to be used in the clean-up.**

Carefully pour approximately 10 mL of 6 *M* hydrochloric acid into a 50-mL beaker. Then pour the 10 mL of 6 *M* hydrochloric acid into the gas measuring tube or eudiometer.

4. While holding the eudiometer in a slightly tipped position, very slowly pour water from the 400 mL beaker into the eudiometer, being careful to layer the water over the acid so that they do not mix. Add enough water to fill the eudiometer completely.
5. Lower the magnesium coil into the water in the eudiometer tube to a depth of about 5 cm. Insert the rubber stopper into the open end of the eudiometer to hold the thread in position. See Figure 14-1. The one-hole stopper should displace some water from the tube. This ensures that no air is left inside the tube.
6. Cover the hole of the stopper with your finger, and invert the eudiometer in the 400 mL beaker of water. Clamp the eudiometer tube into position on the ring stand, as shown in Figure 14-2. The acid flows down the tube (why?) and reacts with the magnesium. Is the acid now more concentrated or more dilute? Describe your observations.

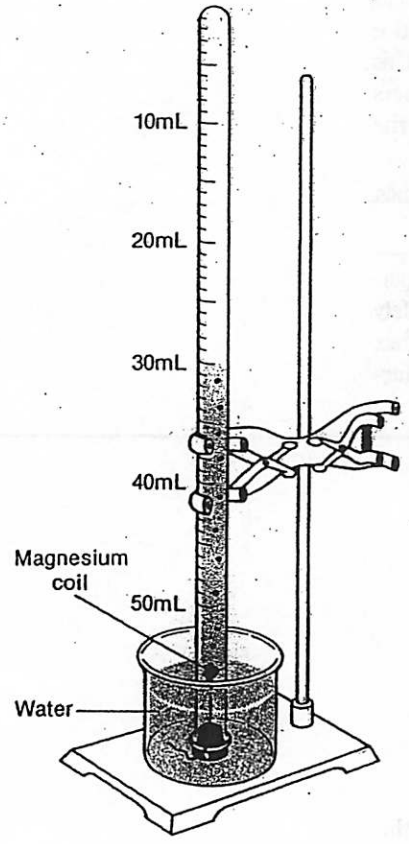

Figure 14-2

7. When the magnesium has disappeared entirely and the reaction has stopped, cover the stopper hole with a finger and carefully transfer the eudiometer tube to a 1000 mL graduated cylinder or other tall vessel that has been filled with water. Adjust the level of the eudiometer tube in the water so that the levels of the liquids inside the eudiometer and the cylinder are the same. See Figure 14-3. Read as accurately as possible the volume of hydrogen liberated.
8. Record the room temperature and pressure.

Strategy for Measuring
In this experiment the pressure of the gas is made equal to atmospheric pressure by equalizing the water levels inside and outside the collection tube.

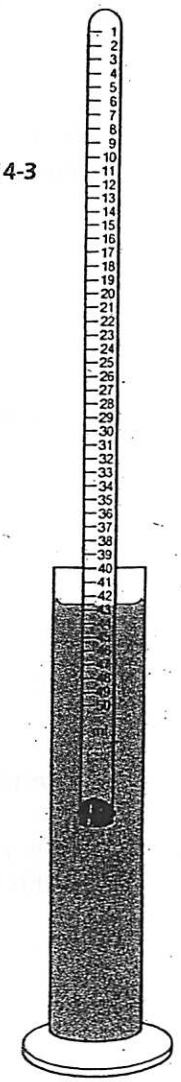

Figure 14-3

Data Table		
Length of Mg Used		cm
Mass per meter of Mg		g/m
Volume of H_2 Collected		mL
Atmospheric Pressure		mm Hg
Temperature of Gas		°C

Calculations (show all of you work with units)

1. Use the mass of one meter of magnesium ribbon and your length of Mg to find the mass of Mg used.

2. From the mass of Mg in the above problem use the molar mass of Mg (24 g/mol) and calculate how many moles of Mg you used.

3. Write the balanced equation of the reaction below. What is the molar ratio between Mg and H_2?

4. Use the number of moles of Mg from question 2 and the molar ratio from question 3 to calculate the number of moles of H_2 produced.

5. Use Boyle's Law ($V_1P_1=V_2P_2$) to adjust the volume of the gas collected from the pressure in the room to standard pressure.

6. Take your volume from 5 and adjust it from room temperature to standard temperature using Charles' Law ($V_1T_2=V_2T_1$).

7. Convert the volume of gas at STP produced from mL to L.

8. Use the volume of the hydrogen at STP and divide it by how many moles of H_2 produced to find the molar volume of a gas at STP.

9. Calculate the experimental error for the experiment using the formula below.

$$\% \text{ error} = \frac{|\text{observed value} - \text{actual value}|}{\text{actual value}} \times 100\%$$

Questions

1. Is your molar volume amount higher or lower than the actual value? Give some sources of error in this lab.

2. From the reaction, how many L of H2 gas could be produced at STP if 2.5 moles of Mg reacted?

3. Since the 1930's aluminum/magnesium alloys have been used to make pots and pans for cooking. What are some examples of foods that could react with these pans?

Answer questions 20-23 on page 274 in the book on a separate sheet of paper and attach it to this lab.